

# VARIATIONS IN HOURLY RAINFALL AT LINCOLN, NEBR.

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(Weather Bureau Office, Lincoln, Nebr., May 16, 1924)

Since the advent of rain insurance there has been an increasing demand for hourly precipitation data. Insurance companies can not establish a satisfactory rate for rain insurance without a full knowledge of hourly rainfall frequency and intensity. These values are not the same for all months of the year, nor for all localities during the same month. For instance, to make a satisfactory rate for rain insurance for Lincoln it is necessary to know that during May more than twice as much rain falls as during October; that May has 50 per cent more hours with rain than October; that the average shower in October lasts 25 minutes longer than the average shower in May; that the time of greatest rain probability is between midnight and 6 a. m. in May, and the time of least probability is between noon and 6 p. m. in August.

This information is of value, not only to insurance companies, but can be used to advantage in many lines of work. Outdoor activities can be planned to better advantage if the average daily weather conditions are known. This is being recognized and the demand for average weather conditions is steadily increasing. With this in mind a rather extended study was made of the hourly rainfall at Lincoln and the results summarized somewhat in detail.

The data presented in this paper cover the 19 years 1905 to 1923 and are for the period May 1 to October 31. In computing the average duration of rains, however, the record for April was also included. The automatic record of hourly rainfall is not maintained regularly during the remainder of the year. Snow fall can not be measured by the automatic rain gauge, nor can the gauge be maintained during freezing weather. Occasionally the record for the automatic gauge is kept during parts of April and November, but with insufficient regularity to be of any value in computing hourly averages.

Tables 1 and 2 show the accumulated amounts of precipitation for each hour of the day for the months May to October, inclusive, for the 19 years. The most noticeable feature is the greater amount of water falling

averaging 45.5 per cent of the total for the month, while from noon to 6 p. m. in August but 6.6 per cent of the total monthly precipitation is recorded. The greatest difference between the amounts accumulated during day and night is in August, averaging 48 per cent more for the night rains, and the least difference is in October, when the night rains average but about 6 per cent more than the day rains.

Tables 3 and 4 and Figures 1-7 show the frequency of rain at the different hours. By frequency is meant the per cent of times rain equaling or exceeding 0.01 inch falls within the hour. A check was made during the entire period of the hours with a trace or more rain, and it was found that in about 44 per cent of the hours with rain the amount was only a trace. As a trace is an amount of rain less than 0.005 inch, it would in most cases be but a light sprinkle, and in some cases but a few drops. As these amounts are too small to affect outdoor activities, it was decided in determining rainfall frequency to consider only hours when the amount of rain equaled or exceeded 0.01 inch.

The month of greatest rainfall frequency is May, and the month of least frequency is August, with July a close second. There is a gradual decrease of rain probability from May to August, with an increase in September and a decrease in October. The greatest frequency is during the night hours, averaging 5.8 per cent, as compared with 4 per cent during the daylight hours. The greatest probability during the night is in May, with an average of 7.8 per cent, and the least during the day is in July, averaging 2.9 per cent. Considering the 6-hour periods, the probability is greatest between midnight and 6 a. m. in May (8.3 per cent), and least between noon and 6 p. m. in August (2.2 per cent) and July (2.5 per cent). The rainiest single hour is between 2 a. m. and 3 a. m. in June (9.5 per cent) and in May (9 per cent). The least probability is between 2 p. m. and 3 p. m. in August (1.2 per cent) and from 1 p. m. to 2 p. m. in July (1.5 per cent). The greatest difference between the day and the night rain frequency is in June, day rains averaging 4 per cent and night rains 7.2 per cent. From June the difference gradually decreases to October, when the day rains average 4.3 per cent and the night rains 4.5 per cent.

TABLE 1.—Hourly amounts of accumulated precipitation, May to October, inclusive, for the 19 years 1905 to 1923, at Lincoln, Nebr.

MONTH	A. M.												P. M.											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
May.....	7.67	3.37	2.76	3.24	3.65	2.74	3.22	1.95	1.90	1.49	1.41	0.84	1.65	2.20	1.71	1.33	2.35	4.17	5.24	3.58	3.86	3.47	3.90	4.14
June.....	6.70	5.51	5.33	4.84	3.31	2.34	3.14	1.26	1.19	2.07	1.52	1.51	1.91	2.38	1.56	1.37	1.23	2.47	2.31	4.70	5.08	6.79	6.53	5.98
July.....	3.14	5.96	2.77	3.12	3.96	2.06	1.99	2.66	2.54	1.79	1.88	1.98	0.85	0.84	1.31	1.15	3.05	3.89	5.52	1.93	3.45	5.41	3.12	4.31
August.....	3.92	5.37	8.13	6.33	5.49	4.05	5.58	4.02	1.31	0.92	1.92	0.91	0.31	0.30	0.23	1.44	0.69	2.03	2.81	2.57	5.07	3.33	4.02	3.67
September.....	4.31	5.80	7.81	5.21	4.04	2.99	3.07	2.93	2.42	2.51	1.98	1.72	1.11	1.35	1.41	4.25	3.13	2.49	3.34	3.26	2.50	1.90	3.65	4.04
October.....	1.35	1.24	2.26	1.44	1.33	1.02	0.80	0.90	0.74	1.15	0.99	1.67	1.24	1.49	1.58	1.75	1.84	1.76	1.82	1.05	1.86	2.06	1.35	1.40
Mean.....	5.42	5.45	5.81	4.84	4.36	3.24	3.58	2.74	2.02	1.99	1.94	1.73	1.41	1.71	1.56	2.26	2.46	3.36	4.21	3.42	4.36	4.59	4.51	4.70

during the night as compared with what falls during the day.<sup>1</sup> For the entire period about 34 per cent of the total amount falls during the 12 hours 6 a. m. to 6 p. m., and about 66 per cent from 6 p. m. to 6 a. m. The ratio differs with the different months, 74 per cent of the August precipitation occurs during the night hours, while in October 53 per cent falls at night and 47 per cent during the day. Considering six-hour periods, the greatest per cent of accumulated precipitation for the different months is to be found from midnight to 6 a. m. in August,

TABLE 2.—Percentage of total monthly precipitation occurring during 6-hour periods, May to October, inclusive, at Lincoln, Nebr.

Month	Midnight to 6 a. m.	6 a. m. to noon	Noon to 6 p. m.	6 p. m. to midnight
	Per cent	Per cent	Per cent	Per cent
May.....	32.6	15.0	18.7	33.7
June.....	34.6	13.2	13.5	38.7
July.....	30.6	18.7	16.1	34.6
August.....	45.5	19.4	6.6	28.5
September.....	39.1	18.9	17.8	24.2
October.....	25.3	18.5	28.3	27.9
Mean.....	34.6	17.3	16.8	31.3

<sup>1</sup> Cf. Kincer, J. B. Daytime and nighttime precipitation. MONTHLY WEATHER REVIEW, 44; 628-633.

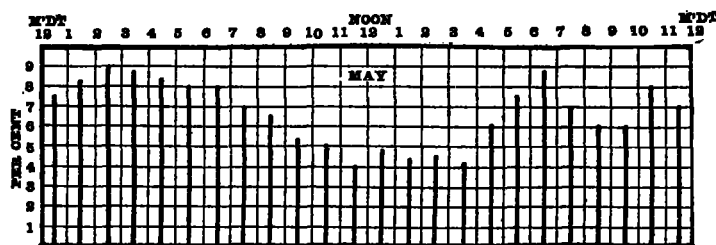


FIG. 1.—Percentage of time rain, equaling or exceeding 0.01 inch, is recorded each hour, at Lincoln, Nebr., during May

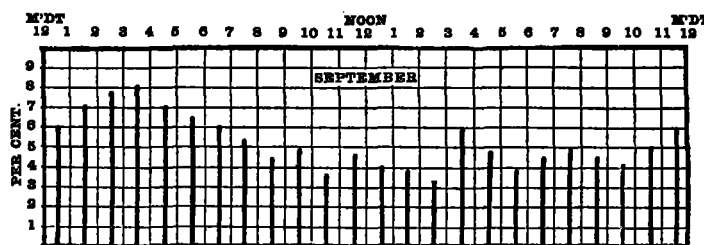


FIG. 2.—Percentage of time rain, equaling or exceeding 0.01 inch, is recorded each hour, at Lincoln, Nebr., during June

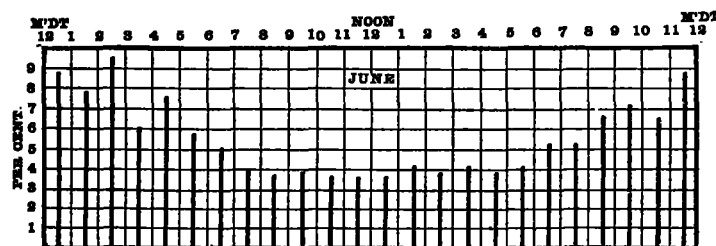


FIG. 3.—Percentage of time rain, equaling or exceeding 0.01 inch, is recorded each hour, at Lincoln, Nebr., during July

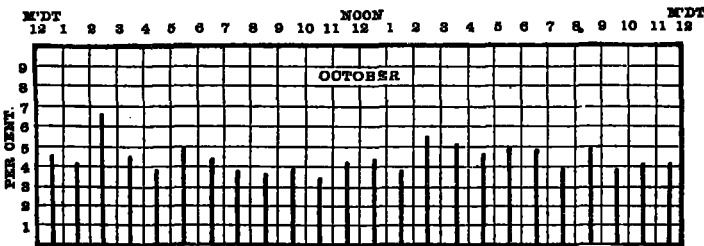


FIG. 4.—Percentage of time rain, equaling or exceeding 0.01 inch is recorded each hour, at Lincoln, Nebr., during August

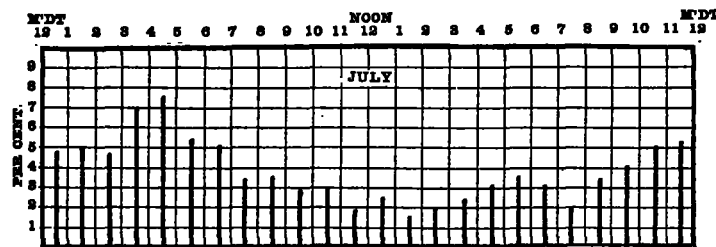


FIG. 5.—Percentage of time rain, equaling or exceeding 0.01 inch, is recorded each hour, at Lincoln, Nebr., during September

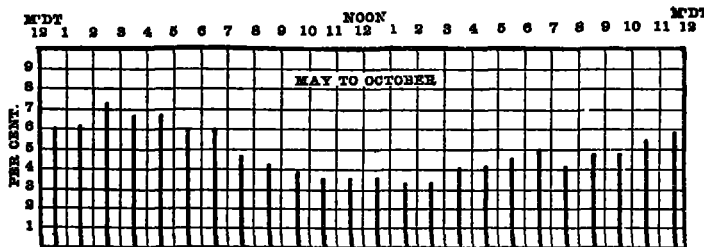


FIG. 6.—Percentage of time rain, equaling or exceeding 0.01 inch, is recorded each hour, at Lincoln, Nebr., during October

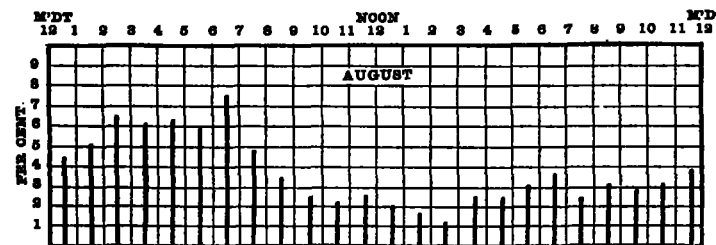


FIG. 7.—Percentage of time rain, equaling or exceeding 0.01 inch, is recorded each hour, at Lincoln, Nebr., during May to October, inclusive

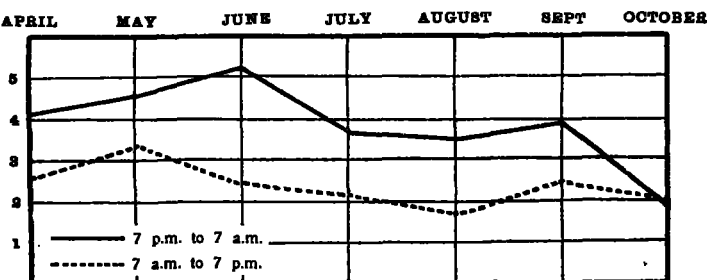


FIG. 8.—Average monthly number of rainfalls equaling or exceeding 0.10 inch

TABLE 3.—Percent age of times rain equaling or exceeding 0.01 inch is recorded each hour at Lincoln, Nebr. (for the hour ending with those given)

Month	A. M.												P. M.												Average
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	
May.....	P. ct. 7.5	P. ct. 8.3	P. ct. 9.0	P. ct. 8.8	P. ct. 8.3	P. ct. 8.0	P. ct. 8.0	P. ct. 7.0	P. ct. 6.5	P. ct. 5.3	P. ct. 5.1	P. ct. 4.1	P. ct. 4.8	P. ct. 4.4	P. ct. 4.6	P. ct. 4.2	P. ct. 6.1	P. ct. 7.6	P. ct. 8.8	P. ct. 7.0	P. ct. 6.1	P. ct. 6.1	P. ct. 8.0	P. ct. 7.0	P. ct. 6.7
June.....	8.8	7.8	9.5	6.0	7.6	5.8	5.1	4.0	3.7	3.9	3.7	3.7	3.7	4.2	3.9	4.2	3.9	4.2	5.3	5.3	6.7	7.2	6.7	8.8	5.6
July.....	4.8	4.9	4.6	7.0	7.5	5.3	5.1	3.4	3.6	2.9	2.9	1.9	2.4	1.5	2.0	2.4	3.2	3.7	3.1	2.0	3.4	4.2	5.1	5.3	3.8
August.....	4.4	5.1	6.5	6.1	6.3	5.8	7.5	4.8	3.4	2.5	2.2	2.5	2.0	1.7	1.2	2.5	2.5	3.1	3.7	2.4	3.1	2.9	3.2	3.9	3.7
September.....	6.0	7.1	7.8	8.1	7.1	6.5	6.1	5.3	4.4	4.9	3.7	4.6	4.0	3.9	3.3	6.0	4.7	3.9	4.4	4.9	4.6	4.2	5.1	6.0	5.3
October.....	4.4	4.1	6.5	4.4	3.9	4.9	4.4	3.9	3.6	3.9	3.4	4.2	4.4	3.9	5.4	5.1	4.6	4.9	4.9	3.9	4.9	3.9	4.1	4.2	4.4
Mean.....	6.0	6.2	7.3	6.7	6.8	6.0	6.0	4.7	4.2	3.9	3.5	3.5	3.6	3.3	3.4	4.1	4.2	4.6	5.0	4.2	4.8	4.8	5.4	5.9	4.9

TABLE 4.—Percentage of times rain equaling or exceeding 0.01 inch is recorded each hour, for 6-hour periods, at Lincoln, Nebr.

Month	Mid. to 6 a. m.	6 a. m. to noon	Noon to 6 p. m.	6 p. m. to mid.	Average
May.....	Per cent 8.3	Per cent 6.0	Per cent 5.3	Per cent 7.2	Per cent 6.7
June.....	7.6	4.0	4.0	6.7	5.6
July.....	5.7	3.3	2.5	3.8	3.8
August.....	5.7	3.8	2.2	3.2	3.7
September.....	7.1	4.8	4.3	4.9	5.3
October.....	4.7	3.9	4.7	4.3	4.4
Mean.....	6.5	4.3	3.8	5.0	4.9

TABLE 5.—Average duration of rains beginning at the different hours at Lincoln, Nebr. (for the hours ending with those given)

Month	A. M.												P. M.												Av.
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	
April.....	H. m. 5 42	H. m. 55 3	H. m. 52 4	H. m. 10 1	H. m. 43 3	H. m. 12 1	H. m. 40 2	H. m. 13 1	H. m. 15 7	H. m. 6 2	H. m. 52 2	H. m. 18 1	H. m. 43 2	H. m. 31 2	H. m. 37 2	H. m. 53 1	H. m. 34 2	H. m. 47 4	H. m. 06 3	H. m. 27 1	H. m. 54 5	H. m. 48 2	H. m. 33 2	H. m. 42 3	H. m. 3 04
May.....	2 40	2 25	2 21	2 18	2 24	2 41	2 23	2 19	2 21	2 18	2 29	2 25	2 08	2 03	2 16	2 07	2 12	2 48	2 29	2 16	2 34	2 28	2 16	2 39	2 27
June.....	2 22	2 51	2 58	2 43	2 31	2 44	2 59	2 31	2 34	2 14	2 53	2 46	2 54	2 56	2 58	2 51	2 56	2 20	2 15	2 12	2 38	2 15	2 39	2 22	2 42
July.....	2 35	2 04	2 00	2 51	2 31	2 23	2 01	2 24	2 38	2 56	2 32	2 45	2 40	2 54	2 50	2 56	2 35	2 41	2 19	2 16	2 23	2 55	2 50	2 46	2 34
August.....	2 19	2 04	2 44	2 32	2 59	2 22	2 46	2 11	2 23	2 08	2 07	2 49	2 50	2 46	2 33	2 41	2 50	2 50	2 18	2 54	2 49	2 27	2 06	2 51	2 21
September.....	2 55	2 48	2 34	2 55	2 52	2 46	2 17	2 13	2 01	2 28	2 23	2 01	2 11	2 39	2 21	2 19	2 14	2 58	2 55	2 17	2 34	2 30	2 22	2 31	2 19
October.....	4 50	6 01	4 43	2 55	2 18	2 28	2 53	2 28	2 05	2 27	2 16	2 32	2 51	2 54	2 24	2 32	2 50	2 25	2 30	2 12	2 20	2 35	2 45	2 52	2 52
Average.....	3 15	3 10	2 19	2 21	2 47	2 58	2 29	2 56	2 20	2 05	2 02	2 02	2 47	2 56	2 45	2 32	2 49	2 29	2 01	2 49	2 44	2 15	2 52	2 48	2 11

TABLE 6.—Average duration of rains beginning at the different hours, for 6-hour periods, at Lincoln, Nebr.

Month	Mid. to 6 a. m.	6 a. m. to Noon	Noon to 6 p. m.	6 p. m. to Mid.
April.....	H. m. 3 28	H. m. 3 04	H. m. 2 21	H. m. 3 25
May.....	2 22	1 53	2 37	2 57
June.....	1 40	1 20	1 22	2 25
July.....	2 08	1 16	0 57	1 55
August.....	1 40	1 06	0 40	1 57
September.....	2 39	1 27	1 29	3 42
October.....	3 22	2 37	2 35	2 55
Average.....	2 28	1 49	1 43	2 45

Tables 5 and 6 show the average duration of rains for the various hours of the day, April to October, inclusive. Duration is the time rain was actually falling. The values in the tables and charts are placed under the hour of the beginning of the rain. For instance, in Table 5 the first entry for April is "5 04," under 1 a. m. This means the average duration of rains in April beginning between midnight and 1 a. m. is 5 hours and 4 minutes.

The average length of rains in April is longer than the rains of any other month. Light drizzles of several hours' duration are not uncommon, lengthening the average duration somewhat. From April there is a decrease in the length of rains until August, when they are short-

est, and then an increase to October. The rains of June, the month of the greatest number of thunderstorms, average 1 hour and 42 minutes in duration, slightly longer than the rains of July and August. The average duration of summer rains is 1 hour 32 minutes, while the rains of spring and autumn average 2 hours 40 minutes. There is a marked difference in the length of day and night rains, night rains averaging 2 hours 36 minutes and day rains 1 hour 46 minutes. The greatest difference in any one month is in September, when night rains average 3 hours 10 minutes and day rains 1 hour 28 minutes. The least difference is in May, when night

rains average 2 hours 40 minutes and day rains 25 minutes less. The longest continued night rains occur in April, averaging 3 hours 26 minutes, while the shortest day rains are in August, averaging 53 minutes. Considering the period as a whole, there seems to be a maximum duration just before and after midnight and again about 10 a. m., and a minimum about 6 a. m. and 3 p. m.

Tables 7 and 8 show the hourly intensity. This is obtained by dividing the accumulated amount of precipitation for each hour by the number of times rains of a trace or more occurred during the hour.

There is a gradual increase in intensity of rains from May to August, when they are heaviest; than a decrease to October, when they are lightest. The greatest difference in the six-hour periods is found in August, when the average intensity between midnight and 6 a. m. is 0.116 inch, and between noon and 6 p. m. is 0.028 inch. The greatest difference between day and night rains is also found in August, when day rains averaged 0.039 inch and night rains 0.110 inch. This is partly due to the fact that in August twice as many thunderstorms occur at night and the heavy downpours accompanying thunderstorms raise the average intensity. During May and October, when thunderstorms are fairly evenly distributed throughout the day and night hours, the difference in intensity between day and night is small. October shows no heavy downpours and but a small variation in day and

night rains. During the summer months heavy night rains are more frequent than during spring and autumn. The day rains of summer, however, are but little heavier than day rains of spring and autumn.

As many insurance companies insure against 0.10 inch of rain, Figure 8 is presented, which gives the average number of times each month a rainfall equaling or exceeding 0.10 inch was recorded during the 12-hour periods ending at 7 a. m. and at 7 p. m. for the 19 years 1905 to 1923. During June night rains equaling or exceeding 0.10 inch were recorded an average of 5.2 times. The greatest number of day rains were recorded in May (3.4) and the least in August (1.8). In October day rains of 0.10 inch or more were slightly more frequent than night rains, the average being 2.1 for day rains and 1.9 for night rains.

The records for the 19 years studied indicated clearly that from May to October night rains at Lincoln were uniformly of more frequent occurrence, of longer duration, and of greater intensity than day rains.

TABLE 7.—Average hourly intensity of rainfall at Lincoln, Nebr. (for the hour ending with those given)

[Total hourly accumulated divided by number of times rain is recorded during the hour]

Month	A. M.												P. M.												Average
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	
May.....	0.108	0.043	0.033	0.042	0.045	0.037	0.039	0.023	0.028	0.025	0.025	0.014	0.025	0.038	0.029	0.024	0.035	0.056	0.069	0.046	0.058	0.055	0.055	0.063	0.042
June.....	.093	.086	.066	.058	.053	.040	.060	.024	.027	.058	.039	.038	.040	.051	.034	.029	.024	.024	.046	.069	.088	.119	.109	.090	.058
July.....	.070	.132	.058	.050	.067	.039	.038	.059	.062	.053	.048	.060	.028	.026	.037	.035	.080	.105	.149	.068	.101	.159	.074	.086	.071
August.....	.096	.122	.163	.122	.096	.095	.086	.082	.028	.022	.055	.030	.009	.009	.010	.060	.020	.062	.078	.092	.127	.085	.130	.105	.074
September.....	.065	.094	.113	.090	.072	.051	.045	.047	.046	.049	.049	.048	.024	.029	.030	.082	.065	.053	.074	.069	.054	.044	.081	.082	.062
October.....	.031	.025	.044	.028	.030	.023	.019	.017	.015	.024	.021	.039	.025	.030	.026	.030	.035	.033	.030	.018	.037	.043	.023	.029	.028
Mean.....	.080	.084	.080	.065	.060	.048	.048	.042	.034	.038	.040	.038	.025	.030	.028	.043	.043	.056	.074	.067	.079	.084	.080	.076	.556

TABLE 8.—Average hourly intensity of rainfall for 6-hour periods at Lincoln, Nebr.

[Total hourly accumulated divided by number of times rain is recorded during the hour]

Month	Midnight to 6 a. m.	6 a. m. to noon	Noon to 6 p. m.	6 p. m. to midnight
May.....	0.051	0.026	0.034	0.058
June.....	.066	.041	.034	.062
July.....	.069	.053	.052	.110
August.....	.116	.050	.028	.103
September.....	.084	.047	.047	.067
October.....	.030	.022	.030	.031
Mean.....	.069	.040	0.38	.077

### 551.577 (781) HOURLY PRECIPITATION AT TOPEKA, KANS.

S. D. FLORA, Meteorologist

[Weather Bureau Offices, Topeka, Kans., February 16, 1924]

To a person acquainted with the peculiarities of the climate of the Middle West and, especially eastern Kansas, where three-fourths of the year's moisture falls in the six summer months and is largely the result of thundershowers, it is a surprise to find that the hour with the heaviest fall of moisture is near sunrise, and the one with the least from noon to 1 p. m. This condition prevails at all times of the year, but is most pronounced in the summer season, which is also the thunderstorm season.

Thundershowers are chiefly the result of great upward rushes of air, due to overheating of the layer near the surface of the earth on warm afternoons, and this cause would naturally be less near sunrise, yet the graph shows

a distribution of rain just opposite of what would be expected. The average fall of rain at Topeka from 5 a. m. to 6 a. m. is more than three times as great as from noon to 1 p. m., and this surprising fact is confirmed by the amounts credited to adjacent hours. More than 60 per cent of the average day's precipitation occurs between 6 p. m. and 6 a. m.<sup>1</sup>

This distribution of precipitation becomes an important matter, especially in the summer months, when most outdoor activities take place. Practically everything done outdoors is subject to interruption or delay by rain. Were the wettest hours at Topeka in the afternoon instead of at night, many lines of human endeavor would be more hampered by unseasonable weather than they now are. Fields and the great stretches of unsurfaced highways dry out rapidly in the warm season of the year in the Middle West, and often after a heavy rain at night field work of certain kinds can be resumed the next day and motorists find properly graded dirt roads passable after a few hours sunshine.

Outdoor gatherings of all kinds, baseball games, picnics, and fairs, depend for their success chiefly on the absence of rain during the afternoon, and this distribution at Topeka has proved peculiarly favorable to them. The growing practice among managers of the more important events to insure against rainfall at specified hours, usually between noon and 6 p. m., has caused a closer study to be made of its distribution through the day, which has been one of the motives in this compilation.



FIG. 1.—Average hourly precipitation, Topeka, Kans., April to September, inclusive, for the period 1905-1923

The hourly records of precipitation at Topeka, like those at other Weather Bureau stations of the first order established more than 19 years ago, have been carefully compiled since the use of station Form No. 1014 was begun January 1, 1905. The means in the table that accompanies this article were obtained from this 19 years' record at Topeka. A few discrepancies have resulted in the record of winter months from moisture which fell

<sup>1</sup> Cf. Kincer, J. B. Daytime and nighttime precipitation. MO. WEA. REV., 44: 628-633.